

## **Addendum 1. Task 3 Response to Comments**

## **Chapter VII Response to Comments**

### **Reviewer Questions:**

#### **Bottom Water Dissolved Oxygen**

*Curiously, most stations in the northern portion of Pleasant Bay did not show any apparent correlation between DO and chlorophyll levels, as would have been expected. Moreover, several stations showed a semi-diurnal, perhaps tidal alternation in DO levels. Almost all of the stations showing seriously depleted levels of DO were in the northern sub-embayments or their tributaries. Yet these same stations also showed diurnal or semi-diurnal alternations with high DO levels in bottom water. How is the surface water that is oxygen enriched by phytoplankton photosynthesis displacing the oxygen depleted bottom water, or are these DO excursions reflecting tidal turnover of the enclosed sub-embayments?*

- Response: It is common for tidal currents to cause exchanges, replacements, and mixing that result in changes in water properties such as DO.

#### **Sediment Entrainment and Biochemical Oxygen Demand**

*The MEP report does not consider the impact of boating activity, although all of the data was collected during the peak of the boating season. Boating activity should have a significant impact on water quality, stirring up and entraining into suspension bottom sediment, which will result in an increase of organic matter and nutrients in the water column. This in turn will increase the biochemical oxygen demand (BOD) and biological activity of the water column resulting in DO depletion. How does boating activity (putting sediment into the water column) contribute to the daily oxygen excursion? What is the impact of boat mooring lines/chains and boat movements in and out of the embayments on dissolved oxygen levels? Put another way, how much of the problem is boating and how much is due to controllable nitrogen loading?*

- Response: This is discussed in Section 3.5.

#### **Historical Eelgrass Distribution**

*Two paramount questions loom as a result of this historical analysis:*

*1- Disregarding the inaccurate and potentially spurious dataset from 1951, the 1995 and 2001 surveys required sufficient water clarity for early morning photography to accurately image the bottom of Pleasant Bay in order to reliably discriminate visually between barren and inhabited substrates. The obvious rhetorical question then remains: how can it be claimed that the decline in eelgrass distribution is a result of shading the substratum by the increased turbidity of enriched phytoplankton populations in surface waters due to nitrogen loading?*

*2- If the distribution of eelgrass has significantly declined in recent years, what ecological attributes might also affect eelgrass viability in addition to nutrient enrichment?*

- Response: We can never be certain about the details of what happened in the past because we were not monitoring the Bay. Disease may have had an effect. We know that changes in circulation have effects both through sediment movements and changes in flushing that modify N concentrations. We do know for sure, from many studies around the world, that excess N loading affects eelgrass negatively.

**Reviewer Questions**

**Re: Dissolved Oxygen:**

***p. 151, para.3 states:***

*“Dissolved oxygen depletion is frequently the proximate cause of habitat quality decline in coastal embayments (the ultimate being nitrogen loading).”*

*What is the relationship between nitrogen in the water column and “depleted oxygen concentrations”?*

*Chemically and biologically, how does nitrogen cause reduced oxygen concentrations?*

*Can oxygen depletion occur in coastal embayments in the absence of excess nitrogen?*

*What role does the capacity of suspended and substrate sediment to absorb oxygen have on the water column?*

- Response: Nitrogen causes hypoxia/anoxia by stimulating organic productivity (algal growth) in the water. Algae respire (use up oxygen) throughout the day. This is more than offset by photosynthesis, but **only during the day**. At night, algae respire and use up oxygen. When algae die their decomposition by bacteria uses up oxygen. This results in more oxygen consumption than production, thus hypoxia/anoxia. This may occur in the absence of excess N, but only in shallow, poorly flushed water bodies.

***p. 153, para. 1 states:***

*“Nitrogen enrichment of embayment water generally manifests itself in the dissolved oxygen record, both through oxygen depletion and through the magnitude of the daily excursion.”*

*How does the chemistry and biology work to affect a reduction in oxygen?*

- Response: This matter is addressed in the response to the previous question.

***p. 154, para. 1 states:***

*“The general pattern is for the high level of oxygen stress (frequent hypoxia or anoxia) in the bottom waters of small enclosed basins (groupA) which tend to have higher nitrogen levels and high rates of sediment metabolism....”*

*How does the nitrogen concentration compare with sediment metabolism; can the latter dominate, even in the presence of elevated concentrations of nitrogen?*

- Response: Sediment metabolism is supported by organic inputs from somewhere, typically from plant production in the waters above the sediments.

***p. 154, para. 2 states:***

*“Salt marsh creeks (that do not empty at low tide) frequently become hypoxic in summer as a result of the high organic matter loading associated with marshes.”*

*Is this independent of nitrogen loading, and could not this same effect be attributed to the small enclosed basins (group A)?*

- Response: Salt marsh plants fix nitrogen if it is deficient around their roots. This supports the high productivity of the marshes. The process stops if N is supplied from elsewhere. I do not know of nitrogen fixers that grow on pond bottoms except for blue-green bacteria, but they would also stop N-fixing if sufficient N were present from elsewhere.

***p. 157, Fig. VII-3, and p. 167, Fig. VII-23, Meetinghouse Pond:***

*What is the cause of the large changes in DO between mid-August and late August; and between early September and later in September?*

*Chlorophyll-a does not show a similar variation over the same periods. Why?*

- Response: This results from both changes in algal production and tidal circulation. We don't have enough data to give a definitive answer.

***p. 159, Fig. VII-8, and p. 169, Fig. VII-28, Arey's Pond:***

*Fig VII-8 shows large daily oxygen excursions starting from 11 July to end July; however, the Chlorophyll-a levels drop significantly from levels prior to 11 July. What is happening?*

*Would you not expect the oxygen excursions to accompany high Chlorophyll-a levels?*

- Response: These sorts of changes result from algal die-off, changes in decomposition rates, changes in tidal flushing, etc. Without being there or collecting measurements at the time, we cannot give a definitive answer. The changes are not surprising or out of the ordinary.

***p. 159, Fig. VII-7, and p. 169, Fig. VII-27, Pochet:***

*Similar observation as for Arey's above except DO excursions seem to change little over the 1 August to 20 September period whereas Chlorophyll-a spikes in mid-August and is relatively flat at just less than 5 µg/l before and after the mid-August period. What is happening?*

- Response: Same response as above.

**Re: Eelgrass:**

***p. 151, para. 3:***

*Eelgrass mapping has been used to indicate the health of the greater Pleasant Bay system. Between the first unvalidated measurements in 1951 and the second in 1995, 44 years elapsed with no measurements of eelgrass area or density. The same is true of observations in Bassing Harbor.*

*How can one conclude that the apparent decline is due only to increases in nitrogen when there is no available data on nitrogen concentrations during this time period?*

*What about the possible effects of disease and or other biotic interactions?*

*In 1983 Pleasant Bay had a boom harvest of more than 70,000 bushels of scallops which are dependent on eelgrass.*

*Would not this indicate that the eelgrass community was healthy in 1983?*

- Response: As indicated in other answers, the significant changes in eelgrass are those in the innermost parts of the Bay system. There is and has been plenty of eelgrass in the better flushed parts of the bay to support scallops.

***p. 182, ¶ 2 states:***

*“However, it is clear from the 1951, 1995 and 2001 temporal sequence that the eelgrass areas in each basin, except Chatham Harbor, are declining in coverage. In The River and Pochet the eelgrass areas were always patchy and in the shallows. By the 2001 survey this pattern continues, but the beds appear to be declining, although they persist.”*  
*Is it clear? On what objective basis?*

*Do the 1951 photographs provide sufficient resolution to support this conclusion?  
Or to support the comment specifically regarding the Pochet and The River eelgrass habitats.*

***Paragraph 1, p188*** *dismisses the idea that other factors may have impacted the eelgrass over 50 years and states: “It is not possible at this time to determine the potential effect of shell fishing on eelgrass bed distribution.”*

- Response: There is no absolute certainty about the cause of any decrease in the past that was not studied at the time. But we do know that N causes eelgrass declines from studies around the world. We do not have data to comment on the effects of current shellfishing on eel grass beds/bay health.

***p. 188, ¶ 6 states:***

*“It is possible to determine a general idea of short- and long-term rates of change in eelgrass coverage from the mapping data, although there are only 3 surveys. Over the 50 year period 1951-2001 the Pleasant Bay System has lost ~583 acres of eelgrass habitat. Interestingly, the rate of loss has been relatively constant at ~11 acres per year. This loss has occurred as watershed nitrogen loading rates gradually increased several fold due to changes in land use within the Pleasant Bay watershed.”*

*Considering :*

- 1. the inferior quality and scale of the photographs utilized to estimate eelgrass habitat area in 1951;*
- 2. an unknown margin of error on all three estimates (1951, 1995 and 2001);*
- 3. the report does not consider the impact of shellfishing activity or natural phenomenon such as disease and hydrology; how is it possible to conclude that eelgrass habitat has decreased “at a relatively constant” 11 acres per year?*

*On what data is the statement “nitrogen loading rates gradually increased several fold” based? How much is known about the nitrogen loading (natural and humanmade) in 1951?*

*In fact, the report states that eelgrass is present in all of the areas where it was in 1951. For The River and Pochet, the two areas suspected to have suffered decline in the 50 year period, the report acknowledges that the “eelgrass areas were always patchy” and in the following sentence states that “ the beds appear to be declining”. The report does not provide objective evidence for this conclusion; nor does the report give meaningful consideration to the possibility that other factors may have played a part in any changes in the eelgrass coverage.*

*Where can one find absolute and definitive evidence bearing on the relationship between dissolved nitrogen concentrations in estuaries and eelgrass viability? Does such exist?*

- **Response:** Perhaps it is best to ignore the 1951 data since the photos are of questionable validity for this purpose. There is also general uncertainty with interpreting eel grass acreage from aerial photos. Absent extensive historical field measurements, however, aerial photographs provide the available evidence to examine trends. Ignoring, the 1951 photos, we see a 25% decline in the '95 to '00 data for the Bassing Harbor sub-system, for example. The question of other causes is always there, and we have no way to go back to confirm what they could have been. We do know that N concentrations have an effect and could reasonably be the cause of the latter decline. We also know that the central part of the Bay has healthy eelgrass. The declines that matter are those in the upper, more enclosed parts of the system.

## **Chapter VIII Response to Comments**

### **Reviewer Questions:**

*p. 200, ¶4: Dissolved Oxygen. S Mast describes the high level of oxygen stress in the sub-embayments. “These small enclosed basins tend to have higher nitrogen levels and high rates of sediment metabolism associated with their circulation and focus of watershed nitrogen loads.” Consequently, S Mast relates bio-activity stress due to low oxygen to elevated nitrogen levels. It is correct that septic nitrogen in the form of ammonia or urea consumes oxygen in their oxidation to nitrates, but is the oxygen stress totally related to increased septic nitrogen concentrations?*

- Response: Addressed in Section 1.7.2 of the Draft Report.

*p. 201, ¶1: “Salt marsh creeks (that do not empty at low tide) frequently become hypoxic in summer as a result of high organic matter loading associated with marshes. Even pristine salt marshes can exhibit this behavior.” Don’t the sub-embayments, such as Meetinghouse and Arey’s Ponds collect organic matter? Is it possible that the hypoxia in these “A ponds” is caused by similar mechanisms to those in the marshes?*

- Response: Addressed in Section 1.7.2 of the Draft Report.

*p.202, ¶1: “As for the oxygen and chlorophyll indicators and the distribution of sediment metabolism, the enclosed basins (Group A, above) are generally significantly to severely impaired relative to the benthic infaunal habitat quality.” It appears that to accept this premise that the impairment is related to low oxygen and chlorophyll, one must accept the fact that septic nitrogen is the primary cause of deplete oxygen. Is it possible that the same mechanisms that occur in marshes occur in the Group A subembayments?*

- Response: Addressed in Section 1.7.2 of the Draft Report.

*p. 204, ¶1 and 2:*

*“the restoration target should reflect both recent pre-degradation habitat quality and be reasonably achievable.” “The threshold nitrogen level for an embayment represents the tidally averaged water column concentration of nitrogen that will support the habitat quality being sought.”*

- Response: Addressed in Section 1.7.2 of the Draft Report.

*p. 204, ¶5 :*

*“After the sentinel sub-system (or systems) is selected, the nitrogen level associated with high and stable habitat quality typically derived from a lower reach of the same system or an adjacent embayment is used as the nitrogen concentration target.”  
Is this a reasonable approach?*

- Response: It is reasonable since the selected embayments do not show damage. A recent summary of eelgrass in Chesapeake Bay recommends a N threshold of <0.15 mg/l, similar to that recommended by MEP for Pleasant Bay.

*p. 205, ¶ 1: What is the support for the notion that dissolved organic nitrogen is nonreactive in the marine environment? What are the sources of dissolved organic nitrogen?*

- Response: Addressed in Section 1.7.2 of the Draft Report.

*p. 205, ¶ 2: The nitrogen threshold of 0.16 mg bioactive nitrogen/liter was set based on a Dec. 2003 MEP Report for Bassing Harbor. What if it were 0.17? Or 0.18? How is the determination made? Note that the data in Chapter VII, Table VII-7, eelgrass areas declined from 246 to 114 acres between 1951 and 2000. Was the concentration of bioactive nitrogen less than 0.16 mg/liter during this 50 year period? Especially from 1951 to the early 1980s when the building boom occurred? Again, is bioactive nitrogen the only real culprit?*

- Response: The first part of the question incorporates the 1951 data, which we believe have substantial uncertainty and may be inaccurate. We do not have 50 years of biogeochemical data for the bay, so can never know whether or not there are other culprits. However, based on what we do know and the response to the comment on p204 ¶ 5 above, 0.15 to 0.16 ml/l seems reasonable as a N threshold.

*p. 205, ¶ 3: “Ryder Cove represents a system capable of fully supporting eelgrass beds and stable high quality habitat based upon the 1951 – 2000 surveys. At present, this basin is transitioning from high to low habitat quality in response to increased nitrogen loading.” So... if Bassing Harbor has had high quality water column in terms of bioactive nitrogen until recently, why did the eelgrass population decline between 1951 and 1995? Are there other potential causes of eelgrass decline that are not included in the SMAST assessment?*

- Response: As suggested in the response to Chapter VII comments, it may be best to ignore the 1951 data since there is substantial uncertainty. Then we just see a 25% decline in the '95 to '00 data for the Bassing Harbor sub-system. The question of other causes is always there, and we have no way to go back to see what they could have been. We do know that N concentrations have an effect and could reasonably be the cause of the latter decline.

*p. 206, ¶ 1:*

*“Unfortunately, total nitrogen within this system appears to be very high. In fact, the whole of lower Pleasant Bay appears to contain very high levels of total nitrogen. Analysis of the composition of the watercolumn nitrogen pool within these embayments revealed that the concentrations of dissolved inorganic nitrogen (DIN) and particulate organic nitrogen (PON) were the same as for the Stage Harbor System. In fact, the level of these combined pools (DIN+PON) was lower in Bassing Harbor (0.133 mg N L-1)*

than in the Stage Harbor (0.158 mg N L<sup>-1</sup>) and the mouth of Oyster River (0.160 mg N L<sup>-1</sup>). Note that the mouth of the Oyster River exhibits a documented stable healthy eelgrass habitat (MEP 2003). It appears that the reason for the higher total nitrogen levels in the Pleasant Bay waters results from the accumulation of dissolved organic nitrogen. The bulk of dissolved organic nitrogen (DON) is relatively non-supportive of phytoplankton production in shallow estuaries, although some fraction is actively cycling. It is likely that the high background DON results from the relatively long residence time of Pleasant Bay waters relative to the smaller systems. This allows the accumulation of the less biologically active nitrogen forms, hence the higher background.

Decomposition of phytoplankton, macroalgae and eelgrass release DON to estuarine waters as do salt marshes and surface freshwater inflows.” (underlines added) The quotation indicates that the very high total nitrogen levels in Pleasant Bay are not expected or well understood. The text “explains” the phenomenon using the phrases “It is likely” and “It appears” throughout. It seems that the explanation is a pure conjecture without any facts to back it up. Since the crux of this matter is about how much nitrogen is in Pleasant Bay, how it moves in and out of the bay and how it impacts the flora and fauna in the bay, it would seem important to have and understand the facts about the nitrogen levels in the bay.

- Response: Total nitrogen includes nitrogen in compounds that are slow to degrade and therefore do not release their nitrogen for use by plants. Compounds such as lignin fit this category. So it is not suitable to include them when calculating the amount of nitrogen that is causing eutrophication. Bioactive nitrogen is nitrogen contained in compounds that are readily degraded, so release their nitrogen for uptake by plants. This includes nitrogen that is already in inorganic form and usable by plants. So when there is high total nitrogen it is essential to use just the bioactive portion in any system where there is flushing that will remove the resistant fraction. MEP did not include PON in their active fraction. If they had, the available nitrogen would have been larger; I do not know if this would have made a significant difference. We do not know why the TN is so high within the system. We agree it would be good to know “why”, but not knowing “why” does not make the number wrong.

**p. 206, last ¶:**

“moving into the mouth of The River (PBA-13) and the lowermost basin of Pochet (WMO-03) eelgrass coverage appears to have declined since 1951, although eelgrass is still present. This loss of beds indicates that the habitat quality has become impaired, but since eelgrass remains, the impairment is judged to be “moderate.”

(see p.182, para. 2: “...smaller eelgrass areas in Pochet and fringing shallow areas in The River and Meetinghouse Pond. ....However, it is clear from the 1951, 1995 and 2001 temporal sequence that the eelgrass areas in each basin, except Chatham Harbor, are declining in coverage. In The River and Pochet the eelgrass areas were always patchy and in the shallows. By the 2001 survey this pattern continues, but the beds appear to be declining, although they persist.”)

Given the inferiority of the 1951 photos and the lack of any field verification, the thesis that eelgrass has been declining from 1951 to 2001 corresponding to an increasing rate

*of nitrogen introduction to the bay is lacking in credibility. Furthermore, the report does not present convincing evidence that 0.16 mg/L is a critical nitrogen level. Where is the body of scientific research showing the relationship between nitrogen concentration and eelgrass success?*

- Response: Research from other areas suggests that 0.15 mg N/l is an appropriate N concentration. This is about what MEP suggests. References to this are contained throughout the report. The data in the report from Applied Coastal Research and Engineering, Inc. indicate a decrease of 0.015 mg/l between 2004 and 2008 as a result of the breach but these results are from the model. Other recent monitoring data suggest the bio-active N concentration has reduced in recent years, for instance at Namequoit Point. A decrease in N concentration at Namequoit Point would be expected once the breach opened.

*p. 208, ¶ 2: “While these systems [drowned kettle ponds] may not be supportive of eelgrass habitat, they are generally capable of supporting healthy benthic animal habitat. Infaunal animals are sensitive to the organic matter loading and resultant periodic oxygen depletions associated nitrogen overloading. Since these conditions typically occur at higher nitrogen loads than does the shading of the bottom by increased phytoplankton production (principal cause of eelgrass loss), the nitrogen threshold level for healthy benthic animal habitat is higher than for healthy eelgrass habitat.” How important, in relative terms, are “organic matter” and the “nitrogen concentrations” in supporting a healthy benthic habitat? SMAST appears to consider the loss of eelgrass to be solely attributed to bioactive nitrogen in the water column, and ignores other mechanisms that contribute to eelgrass loss!*

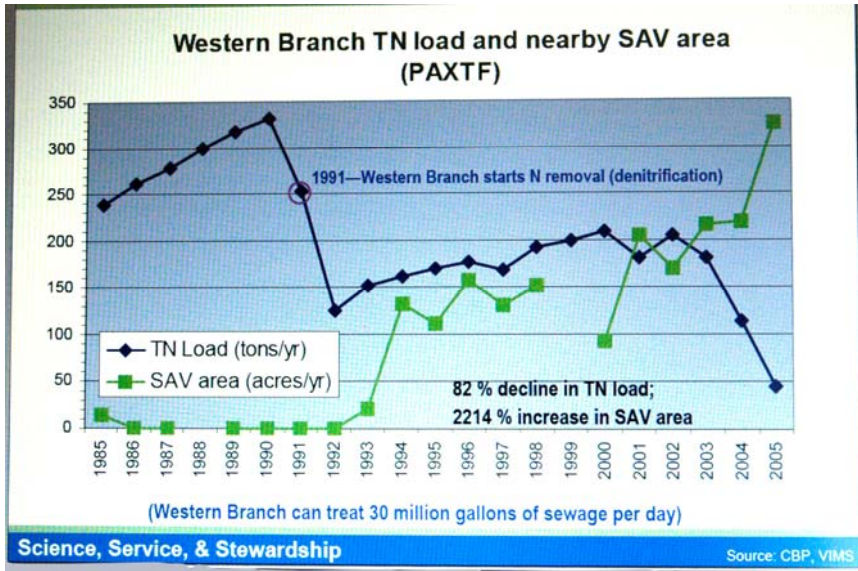
- Response: There is no absolute certainty about the cause of any decrease in the past that was not studied at the time. But Short and others have shown that plants at full salinity are much more susceptible to the wasting disease than those at brackish conditions. Their data only distinguish salinities above and below 15ppt so disease could potentially affect most of Pleasant Bay.

*p. 208, last ¶:*

*After describing successful amphipod communities in the Orleans ponds where the bioactive nitrogen concentration varies apparently varies from 0.2 to 0.4 mg/l, the report concludes that 0.21mg/l should be established as the threshold concentration for benthic infauna. Why 0.21? Why not 0.28 or .030?*

- Response: The following slide is from Peter Bergstrom at NOAA from a meeting in China in 2006 shown here without explicit permission [so it should not be reproduced elsewhere beyond this comment]. The figure illustrates the recovery of eelgrass (SAV= submerged aquatic vegetation) after reductions in N in a branch of the Patuxent River. Another example from “Connecticut Fish Tips and News” from the work of Vaudrey at the University of Connecticut showed recovery of eelgrass in Mumford Cove after the removal of a sewage outfall in 1987. The article is from August 2007. This is 20 years after the nitrogen

removal but recovery may have been quicker. The website “[www.mass.gov/dfwele/dmf/programsandprojects/hubline/eelgrass\\_update\\_021408.pdf](http://www.mass.gov/dfwele/dmf/programsandprojects/hubline/eelgrass_update_021408.pdf)” gives results from eelgrass restoration in Boston harbor after the sewage cleanup but there are no N data.



**p. 209, final 2 sentences:**

*“Therefore restoration success will be gauged by reaching the target at the sentinel station and at the secondary stations for eelgrass (Ryders Cove) and infauna. Overall there are three primary(PBA-12, PBA-03 and CM-13.) and 8 secondary target stations within this System, the largest embayment on Cape Cod.”*

*This states that both the sentinel station and the secondary station must meet targets. The targets are shown in Table VIII-2, which contains both Bioactive Nitrogen thresholds and Total Nitrogen Thresholds for all 8 secondary stations, 6 of which are in Orleans. This seems inconsistent with the statement on p. 204 i.e.,*

*“.....to first identify a sentinel station within the embayment .....is selected such the restoration of the one site will necessarily bring the other regions of the system to acceptable habitat quality levels.”*

*These multiplicity of requirements and seemingly conflicting statements need to be resolved.*

- Response: Because the Bay is large and has many subsystems, they feel that several sentinel stations in different parts of the Bay are needed. The statement on P. 204 probably refers to each subsystem, not to the Bay as a whole.